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WITNESS my hand this
Thirtieth day of November 1999

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ORIGINAL

A U S T R A L I A

Patents Act 1990

PROVISIONAL SPECIFICATION FOR THE INVENTION ENTITLED:

APPARATUS FOR CONTROLLED VENTING OF A CHAMBER

The invention is described in the following statement:

FIELD OF THE INVENTION

The present invention relates generally to the delay of deterioration of perishable products by the management of the composition of the atmosphere in contact with the product and to apparatus therefor.

BACKGROUND OF INVENTION

Many items of perishable produce respire after harvest. That is they consume oxygen and produce carbon dioxide. It is known that if the rate of respiration can be slowed during transportation, the produce will degrade less. The rate of respiration can be controlled by controlling the amount of oxygen and/or carbon dioxide available to the produce.

Many items of produce deteriorate after removal from the plant. This deterioration which is usually given the term senescence, can be delayed by enclosing the perishable product in a chamber to which is applied well recognised methods, such as reduction of temperature below ambient room temperature, and/or the reduction of the concentration of oxygen below that occurring in air, and/or the elevation of the concentration of carbon dioxide above the concentration occurring naturally in air. Each of these conditions may be applied alone or in combination with any or all of the others.

However if the oxygen concentration is reduced too much or the carbon dioxide concentration rises too high, then the perishable product may be injured, resulting in even more rapid deterioration than might occur if no treatment was applied. Consequently it is desirable to be able to adjust the composition of the atmosphere within the chamber and apparatus for adjusting the atmosphere in the chamber has accordingly been developed.

For transportation of perishable produce, the chamber referred to may be a shipping container, which in a common form may be fitted with a refrigeration system to adjust the temperature.

Controlled atmosphere containers are usually purpose built. However, controlled atmosphere apparatus may also be installed in a refrigerated container following a time-consuming and expensive operation.

Controlled atmosphere containers must be substantially sealed in order to separate the controlled atmosphere from the ambient atmosphere. It has been found that the door seals in controlled atmosphere containers are generally the source of most leakage. Every time the door is opened the seal is broken.

In one existing apparatus for controlling the atmosphere in a container, the atmosphere is taken from the container and passed through a device for actively modifying

the atmosphere such as a carbon dioxide absorption tower and the modified atmosphere reintroduced into the container. The various devices for actively modifying the container atmosphere are expensive and generally difficult to service during transportation.

Where such apparatus is to be used to convert a refrigerated container to a controlled atmosphere container, holes may need to be made in the container walls to allow the container atmosphere to be drawn from the container to be modified and returned to the container. Such a process may need a permanent modification to be made to a refrigerated container and would be time consuming and expensive.

SUMMARY OF INVENTION

The present invention accordingly provides in one embodiment atmosphere adjustment apparatus for adjusting the atmosphere within a chamber. The present invention also provides in another embodiment an adjusted atmosphere chamber which incorporates atmosphere adjustment apparatus according to the present invention.

A chamber according to the present invention may be provided within any form of receptacle.

The invention is particularly applicable to chambers provided within a receptacle in the form of a shipping container. While it is convenient to hereinafter describe the invention in relation to that example application it is to be appreciated that the present invention is equally applicable to chambers provided by or within other forms of receptacle including cool stores, refrigerated vans, rail cars and other storage facilities.

The present invention accordingly provides in yet another embodiment a method for converting a refrigerated shipping container to an adjusted atmosphere refrigerated shipping container incorporating the atmosphere adjustment apparatus provided by the present invention.

In a still further embodiment the present invention provides a method for transporting perishable produce in an adjusted atmosphere chamber incorporating the atmosphere adjustment apparatus provided by the present invention.

The atmosphere adjustment apparatus provided by the present invention includes sealing means, inlet means, outlet means and a controller.

Sealing means according to the present invention is provided to substantially seal the chamber, ie. a volume available within the receptacle for storing produce in an adjusted atmosphere.

Where a chamber according to the present invention contains respiring produce, preferably the chamber is sealed to a sufficient extent that the rate of consumption of oxygen within the chamber exceeds the rate of leakage of oxygen into the chamber.

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The sealing means may act as a moisture barrier. The sealing means may act as a barrier to the passage of gas into or out of the chamber. The chamber may comprise substantially the entire internal volume of the receptacle or a reduced volume within the chamber.

The point of entry to a chamber is liable to leak. The point of entry to a chamber is typically in the form of one or more doors. In particular, it has been found that for shipping containers, the seals of the doors of the container are generally the source of most leakage. Consequently, the sealing means provided in accordance with the present invention may include door sealing means.

The sealing means provided by the present invention may also include a curtain. The curtain may comprise a substantially fluid impervious sheet. The curtain may substantially seal an open end of a receptacle to form the chamber.

A curtain may be attached to the internal walls of the receptacle by any suitable means such as an adhesive including tape or glue. The curtain may seal the chamber from leakage paths in the receptacle that are outside the chamber. In particular, the curtain may seal the chamber from any leakage paths in the door seals of the receptacle by being interposed between the chamber and receptacle door.

A curtain according to one aspect of the present invention is preferably located close to the door of the receptacle in order to maximise the volume of the chamber. The curtain is preferably approximately coplanar with the receptacle door when the curtain is in a substantially un-deformed state where there is equal pressure on either side of the curtain.

Refrigerated shipping containers (sometimes known as reefer containers) are generally of a standard style of construction. Such containers typically have a false floor. The produce sits on the false floor which is spaced from the outer wall of the container to facilitate air flow within the container. The false floor typically terminates a short distance from the end of the container to facilitate air flow at the ends of the load stored within the container.

The curtain is preferably located within the space between the container door and the beginning of the false floor.

In this arrangement the chamber is accordingly bounded by the container walls and the curtain with the space between the curtain and the container door being outside the chamber.

The sealing means provided in accordance with the present invention may also include a cover for any ventilation port in the shipping container or other receptacle. The cover may comprise a sheet of flexible material such as an expanded rubber sheet. The sheet may be initially oversized and subsequently trimmed on site to form a cover which

matches the profile of the ventilation port whereby to seal it. The cover may be installed over the ventilation port by any means. Preferably the cover is adhered to the port and/or the wall immediately surrounding the port with tape and/or glue. Where a port comprises a number of apertures, one or more covers may be used to seal the port.

The cover is preferably substantially impermeable. The cover may include one or more layers which are not substantially impermeable. In this case, the cover may include a substantially impermeable layer such as an adhesive sheet to adhere the cover to the port and/or the wall immediately surrounding the port. The substantially impermeable adhesive sheet is preferably applied so as to substantially cover the permeable material. In this way the cover may be rendered substantially impermeable.

The inlet and outlet means provided in accordance with the present invention may be operable to facilitate respectively the inflow of ambient atmosphere into the chamber and the outflow of adjusted atmosphere from the chamber.

The inlet and outlet means may each comprise one or more valves operable to provide in an open position communication between the adjusted atmosphere within the chamber and the ambient atmosphere surrounding the chamber. Each valve may be operable in a closed position to substantially restrict such communication.

The inlet means and the outlet means each may be located in any boundary of the chamber.

In a typical arrangement, the outlet means is located adjacent to a fan provided in the chamber for circulating air within the chamber. Preferably, the outlet means is mounted in a ventilation port near the fan. In the case of a standard refrigerated shipping container having a fan at one end of the container, the outlet means is preferably mounted in the ventilation port that is typically located adjacent to the fan.

The outlet means is preferably located on the high pressure side of the fan so that when the outlet means is open, adjusted atmosphere is forced out of the chamber.

The inlet means is preferably spaced from the outlet means. Preferably the arrangement of the inlet means and outlet means is such as to facilitate the free flow of atmosphere between the interior and exterior of the chamber. Most preferably the inlet and outlet means are positioned relative to one another so as to facilitate cross-flow ventilation when each is in the open position.

Most preferably the inlet and outlet means are located at either end of the chamber. The inlet means may be mounted in a curtain according to the present invention. In this case, installation of the curtain also includes installation of the inlet means. The inlet means and the outlet means may each include a plurality of valves. Such valves may be spaced from one another in locations which facilitate the desired air flow.

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The valves comprising the inlet and outlet means may be operable in response to a signal from the controller. Each valve may be connected to the controller by wire or other means for conveying a signal from the controller to the valve.

Each valve provided according to the present invention may be magnetically operable between an open position and a closed position. A solenoid is preferably provided to generate a magnetic field in response to the application of a direct current whereby to urge the valve toward an open or a closed position dependent upon current direction.

In one preferred form a valve comprises a magnetic member moveable along a bore in response to the field generated by passing a direct current through a solenoid surrounding the bore. The member may be captured within the bore and moveable between positions which open and close the valve.

In another preferred form the valve comprises a flap moveable under the application of a magnetic field between open and closed positions. The flap may carry a magnet. The flap may be hingedly mounted with respect to a base. The base may carry a solenoid or coil for generating a magnetic field to open or close the flap and hence the valve in response to a signal from the controller.

Where there is a curtain according to the present invention that is flexible, the differential between the pressures of the atmospheres on each side of the curtain may vary at different points on the curtain. This variation can cause the curtain to move somewhat erratically. To facilitate equalisation of the pressure differential over the surface of the curtain, the curtain may be provided with inlet means in the form of valves that are spaced apart. In a typical arrangement a curtain may carry inlet means in the form of a pair of valves. One valve may be located in the upper portion and the other in the lower portion of the curtain.

As can be appreciated by those skilled in the art, the above described preferred locations of the outlet means and the inlet means may be interchanged whereby the outlet means may be located in a curtain according to the present invention and the inlet means may be located near the fan. In this configuration the inlet means communicates with one of the apertures of the ventilation port that is located near the fan provided in the chamber for circulating air within the chamber. Such an inlet means is to be located on the low pressure side of the fan so that when the inlet means is open, the atmosphere outside the controlled space is pushed into the controlled space. In this arrangement outlet means may be mounted in a curtain according to the present invention.

A controller according to the present invention may include sensor means and control means. The sensor means may be operable for sensing the concentration of oxygen, carbon dioxide, humidity or other variable within the chamber. Preferably the

sensor means includes an oxygen concentration measurement device which provides an output in the form of an electrical signal containing information about the oxygen concentration level within the chamber. Such an electrical signal may be a direct current signal having voltage proportional to oxygen concentration or the signal may digitally encode the oxygen concentration level or a number that is proportional, or otherwise in known relation to, the oxygen concentration. Other forms of output are also envisaged within the scope of the present invention.

A controller according to the present invention may include means to receive and respond to the sensor means output. Such response may include activating one or more valves or other devices subject to the control of the controller. The controller may be operatively connected to the valves by direct wire connection or other means for facilitating the activation of one or more valves by the controller. The controller may receive signals from the sensor means continuously or may sample the signals discontinuously. Where the signals are sampled discontinuously, the sampling intervals may be equal or unequal. The sampling interval may be made to vary according to the output of the sensor means or may be fixed.

The atmosphere adjustment apparatus provided in accordance with the invention may further optionally include modification means for modifying the atmosphere within the chamber. The modification means may include active and/or passive means for increasing or decreasing the concentration of a component of the atmosphere in the chamber. Components which may be controlled using modification means include carbon dioxide, ethylene and humidity among others. Modification means according to the present invention may be operable by the controller.

Modification means according to the present invention preferably includes a passive carbon dioxide concentration reduction means. Preferably the reduction means comprises a predetermined quantity of a suitable substance for extracting carbon dioxide from the atmosphere, such as hydrated lime, held in carbon dioxide transmissible bags. Such reduction means is already known in the art. The quantity of suitable substance to be placed within the chamber may be calculated from a knowledge of the total amount of carbon dioxide above the maximum tolerable amount of carbon dioxide within the chamber that is likely to enter the chamber and/or be produced through respiration of produce. This maximum amount may be estimated from a knowledge of the temperature at which the chamber is to be held, the time throughout which the atmosphere is to be adjusted and the respiration rate of the produce to be stored within the chamber.

Modification means according to the present invention may include a humidifier preferably a passive humidifier. A passive humidifier may comprise a tray for catching water dripping from the evaporation coil of a refrigeration unit within the chamber. The

humidifier may include wick means for conveying the water to a point near the fan for circulating air within the chamber so that the moisture may be blown into the chamber to increase the humidity thereof.

After produce has been loaded into a chamber fitted with atmosphere adjustment apparatus according to the present invention the chamber may be flushed with a gas having a low oxygen concentration or containing no oxygen. Nitrogen may be used as the gas. Such a gas flushing step may be effected to lower the initial oxygen concentration within the chamber to below a predetermined maximum oxygen concentration. If the oxygen content is thereby lowered below a predetermined minimum oxygen concentration, the controller may operate to cause the oxygen concentration within the chamber to be increased. If such a gas flushing step were not carried out, it would take considerable time for the oxygen concentration within the chamber to be lowered as a result of consumption of oxygen by produce during respiration.

In use, when the oxygen concentration within the chamber falls below a first predetermined minimum value, the controller causes both the inlet means and the outlet means to open for a first predetermined length of time so as to allow air surrounding the chamber to enter the chamber and atmosphere from within the chamber to exit the chamber.

The influx of air into the chamber will thereby increase the oxygen concentration within the chamber.

If, after the inlet means and outlet means have closed, the oxygen concentration as measured by the sensor means has not increased to at least a second predetermined minimum value, the controller may cause both the inlet means and the outlet means to switch to an open state for a second predetermined length of time so as to allow further air surrounding the chamber to enter the chamber and atmosphere from within the chamber to exit the chamber. The second predetermined minimum value of the oxygen concentration may be equal or unequal to the first predetermined minimum value of the oxygen concentration.

This process may be repeated until the oxygen concentration has increased to an acceptable level.

If, after the inlet means and outlet means have closed, the oxygen concentration within the chamber as measured by the sensor means has not increased to at least the second predetermined minimum value, the controller may determine not to cause the inlet means and outlet means to switch to an open state for a second or subsequent predetermined length of time in order to allow time for the oxygen concentration as measured by the sensor means to increase due to mixing of the atmosphere within the chamber.

In a given cycle of increasing the oxygen concentration within the chamber, where the inlet and outlet means are opened for a second or subsequent predetermined length of time, the various predetermined lengths of time may be equal or unequal. Preferably, each subsequent opening of the inlet and outlet means within a single cycle of increasing the oxygen concentration within the chamber is longer than the previous. For example, preferably the second predetermined length of time is longer than the first predetermined length of time, the third is longer than the second and so on.

In a given cycle of increasing the oxygen concentration within the controlled space, where the inlet and outlet means are opened for a second or subsequent predetermined length of time, the various predetermined lengths of time may be adjusted by the controller in response to the measurements of the sensor means.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a schematic side view of a standard refrigerated container fitted with atmosphere adjustment apparatus according to a preferred embodiment of the present invention;

Figure 2 is a side elevation of a valve for use at the machinery end of a refrigerated container in accordance with a preferred embodiment of the present invention;

Figure 3 is a front elevation of the valve according to Figure 2;

Figure 4 is a rear elevation of the valve according to Figure 2;

Figure 5 is a front elevation of a valve for use in a curtain according to the preferred embodiment of Figure 1;

Figure 6 is a rear elevation of the valve according to Figure 4; and

~~Figure 7 is a side elevation of the valve according to Figures 4 and 5.~~

BRIEF DESCRIPTION OF PREFERRED EMBODIMENT

Figure 1 shows a receptacle in the form of refrigerated container 10 which includes refrigeration unit 12 and doors 14.

In the embodiment illustrated the sealing means includes a curtain 16. The curtain preferably comprises an impervious sheet and is attached to the external walls of container 10 with tape (not shown) to form chamber 11. Modification means 9 comprising a quantity of hydrated lime held in carbon dioxide transmissible bags is located within chamber 11.

Sealing means (not shown) in the form of a cover for ventilation port 18 is located at the machinery end of the container 10. The cover comprises an impervious plastic sheet adhered with tape to the wall of the container 10. The cover is adapted to cover, and hence seal, ventilation port 18. The cover is fitted with outlet means in the form of a valve 20.

Valve 20 is located on the high pressure side of the fan so that when valve 20 is open, the adjusted atmosphere is forced out of the chamber.

Inlet means in the form of valves 70 are located in the curtain 16. Ambient atmosphere may enter chamber 11 when valves 70 are open.

Controller 8 includes sensor means (not shown) in the form of an oxygen concentration measurement device. The sensor means preferably takes measurements at equally spaced intervals which may be adjusted depending upon the rate of respiration (if any) of produce in chamber 11. If the oxygen concentration falls below a predetermined value (which can be adjusted depending upon the rate of respiration (if any) of produce in the container), controller 8 sends a signal via wires 17 or other communication means to open valves 70 and 20. This allows the influx of ambient atmosphere into chamber 11 through valves 70 and the discharge of adjusted atmosphere from chamber 11 through valve 20.

As shown in Figure 2, valve 20 includes a casing 22 having a circular cylindrical outer surface 23 and an apertured end piece 24. End piece 24 includes apertures 25 as shown in Figure 3. End piece 24 contains a central circular cylindrical boss 26 as shown in Figure 2 and in dotted outline in Figure 3. Boss 26 contains a magnet 28.

Valve 20 includes spacer rings 30 and 32.

Valve 20 includes a reel 38 provided with flanges 40 and 42 and a central circular bore 44. Wire (not shown) is coiled around the reel 38 between the flanges 40 and 42 to create a solenoid. A spherical ball 60 is located in bore 44 of reel 38. In the preferred embodiment illustrated, the ball 60 is magnetic ie is attracted by a magnet. The

diameter of ball 60 is greater than the length of reel 38 as measured from the outer surface of flange 40 to the outer surface of flange 42 along a line parallel to the axis of bore 44. The diameter of bore 44 exceeds the diameter of ball 60.

A sealing plate 34 is provided having a central circular hole 36 which is substantially concentric with the bore 44. The diameter of the hole 36 is less than the diameter of the ball 60.

An end cap 50 is provided having 6 circular apertures 52 and central boss 54 which receives permanent magnet 56.

The valve 20 is closed when the ball 60 is located so as to seal the hole 36 in the sealing plate 34 so that no fluid may pass through the bore 44. In the preferred embodiment illustrated, the valve is held shut by virtue of magnet 28 holding the ball 60 in the closed position. It will be appreciated by those skilled in the art that other means for retaining ball 60 may be adopted.

When valve 20 is to be opened a direct current preferably in the form of a pulse may be applied to the solenoid (not shown) wound around bore 44 whereby to overcome the attractive magnetic force of the magnet 28 and push ball 60 towards magnet 56.

Valve 20 is open when the ball 60 is located so as to bear against the end cap 50. If the direct current pulse ceases, valve 20 is held open by virtue of magnet 56 holding ball 60 in the open position, although it will be appreciated by those skilled in the art that other means for retaining ball 60 may be adopted. For example, valve 20 may be held open by maintaining the current through the solenoid.

When valve 20 is to be closed a direct current preferably in the form of a pulse may be applied to the solenoid in the opposite direction to the valve opening pulse so as to overcome the attractive magnetic force of magnet 56 and push ball 60 towards the open position previously described.

It will be appreciated by those skilled in the art that valve 20 may be held closed by maintaining the current through the solenoid instead of, or in addition to, utilising the effect of magnet 28 on ball 60.

Figures 5 to 7 show an alternative form of valve 70 suitable for mounting on curtain 16. Valve 70 has a base 72, having a hole typically oval or circular. Flap 74 is complementary to the hole in base 72. Seal 75 extends between base 72 and flap 74. Flap 74 is hingedly mounted on base 72 by hinge 76. Magnet 78 is mounted on flap 74. Attached to the base 72 is a coil 80 around a core 82 to form a solenoid.

A spacer 84 is attached to the centre of flap 74. Arm 86, carrying magnet 88, is mounted on spacer 84.

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Spacer 84, arm 86, magnet 88, core 82 and coil 80 are protected by protective shield 91. Protective shield 91 contains airholes 92. Similarly magnet 78 is protected by shield 90.

In figure 7 valve 70 is shown in the closed position. In the preferred embodiment, valve 70 is held closed by the magnetic attraction between magnet 78 and core 82 of the solenoid, although it will be appreciated by those skilled in the art that other means for retaining flap 78 may be adopted.

When valve 70 is to be opened, a direct current preferably in the form of a pulse may be applied to solenoid 80 so that core 82 repulses magnet 78 and attracts magnet 88. The attraction of magnet 88 to core 82 drives arm 86 towards core 82 so as to move flap 74 away from seal 75 under the influence of hinge 76 and hence open valve 70. If the direct current pulse ceases valve 70 is held open by the magnetic attraction between magnet 88 and core 82. It will be appreciated by those skilled in the art that other means of retaining arm 86 may be adopted.

When valve 70 is to be closed a direct current or pulse may be applied to solenoid 80 in the opposite direction to the valve opening pulse so that core 82 repulses magnet 88 and attracts magnet 78. Valve 70 is then held closed as previously described.

After produce has been loaded into container 10 curtain 16 is installed thereby forming substantially sealed chamber 11. Chamber 11 is flushed with nitrogen to lower the initial oxygen concentration within the controlled space to below a predetermined maximum oxygen concentration.

During use, if controller 8 senses that the oxygen concentration within the chamber has fallen below a first predetermined minimum value, controller 8 sends a signal via wires 17 which causes both the inlet means and the outlet means in the form of valves 70 and 20 respectively to open for a first predetermined length of time so as to allow air surrounding the chamber to enter chamber 11 and adjusted atmosphere within the chamber to leave chamber 11 under the influence of the fan.

The influx of air into chamber 11 thereby increases the oxygen concentration within chamber 11.

If, after valves 70 and 20 are closed, the oxygen concentration as measured by the sensor means has not increased to at least a second predetermined minimum value, controller 8 causes both valves 70 and 20 to switch to an open state for a second predetermined length of time so as to allow further air surrounding the chamber to enter chamber 11 and adjusted atmosphere from within chamber 11 to exit chamber 11 under the influence of the fan.

This process is repeated until the oxygen concentration has increased to an acceptable level.

In the embodiment illustrated ambient air is initially drawn into chamber 11 from space 15 between doors 14 and curtain 16. As adjusted atmosphere is driven from chamber 11 under the influence of the fan the pressure within chamber 11 drops.

The drop in pressure within chamber 11 causes curtain 16 to bow inwardly as shown in Figure 1. This action initially reduces the ambient pressure within space 15. However, as there is no need to have airtight door seals on container 10 for the application of the present invention, ambient air from outside container 10 is drawn through or around doors 14 into space 15 and subsequently into chamber 11.

Thus curtain 16 may act as a form of diaphragm moving with changes in respective pressure between chamber 11 and space 15 and acting to equalise the pressure therebetween when valves 70 are open.

The apparatus provided by the present invention is relatively cheap to install. The apparatus can be installed in a variety of receptacles and does not rely on the efficacy of door seals to maintain the atmosphere within the chamber.

Whilst it has been convenient to describe the invention herein in relation to particularly preferred embodiments, it is to be appreciated that other constructions and arrangements are considered as falling within the scope of the invention. Various modifications, alterations, variations and/or additions to the constructions and arrangements described herein are also considered as falling within the scope and ambit of the present invention.

DATED this 19th Day of October 1998

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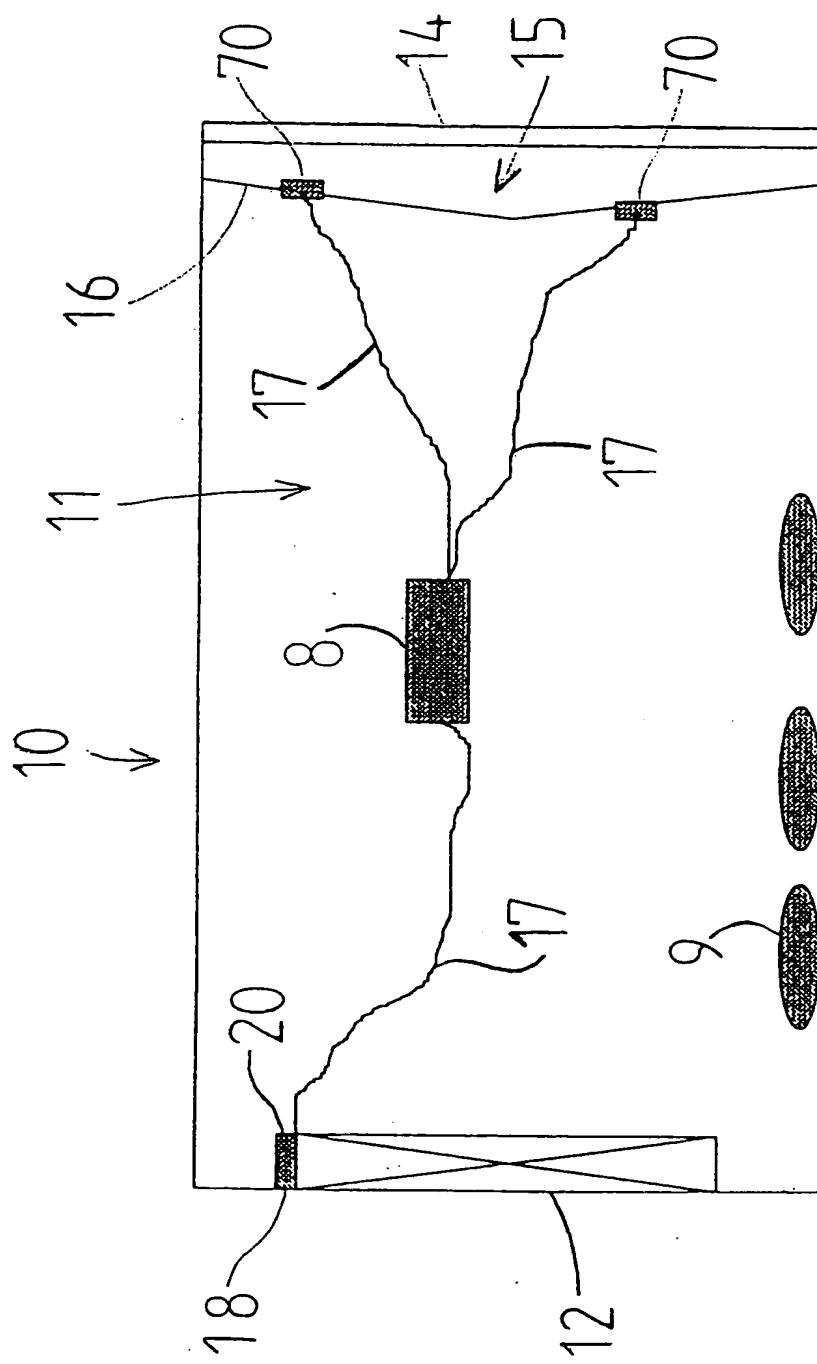


FIG. 1

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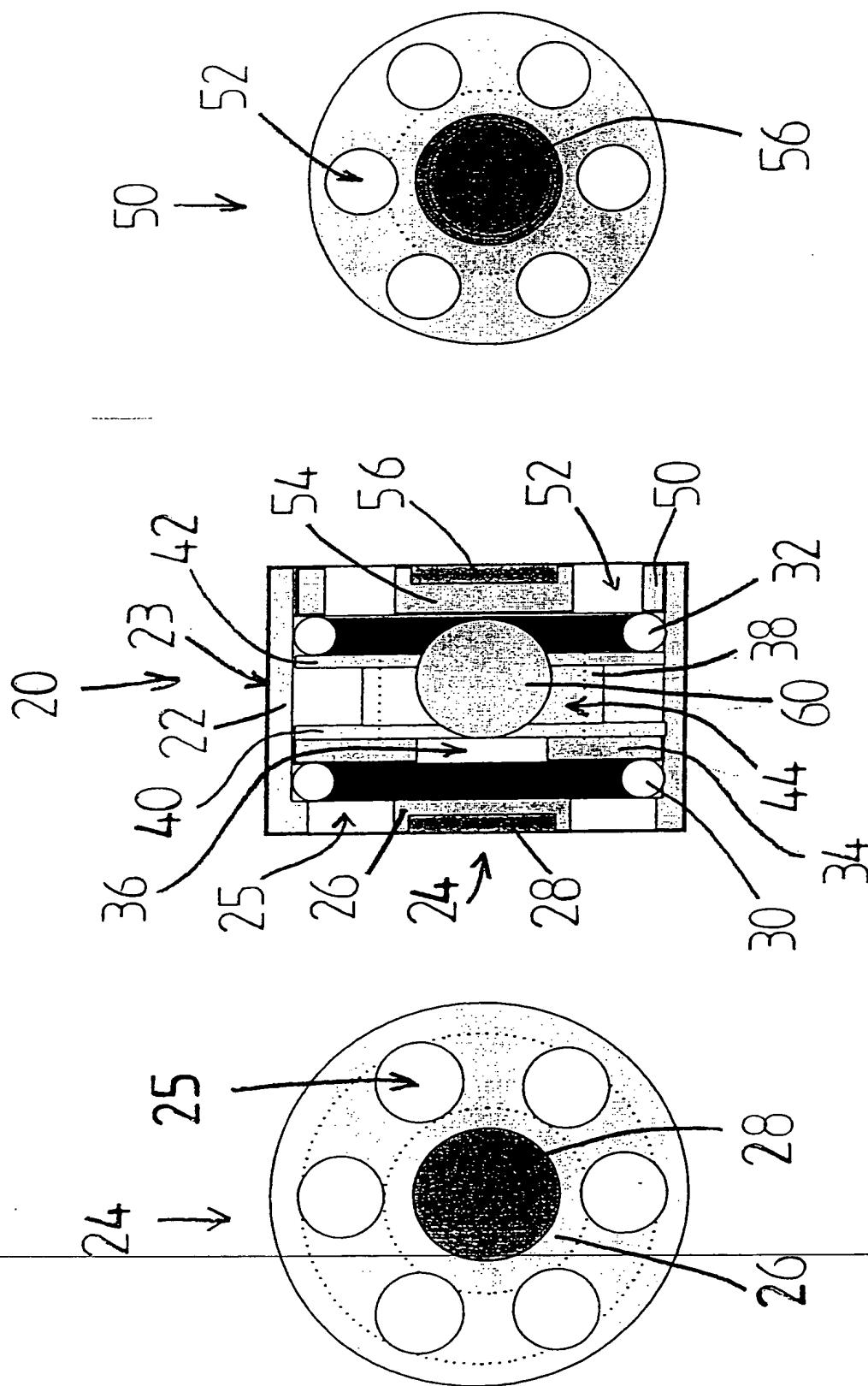


FIG 4

FIG 2

FIG 3

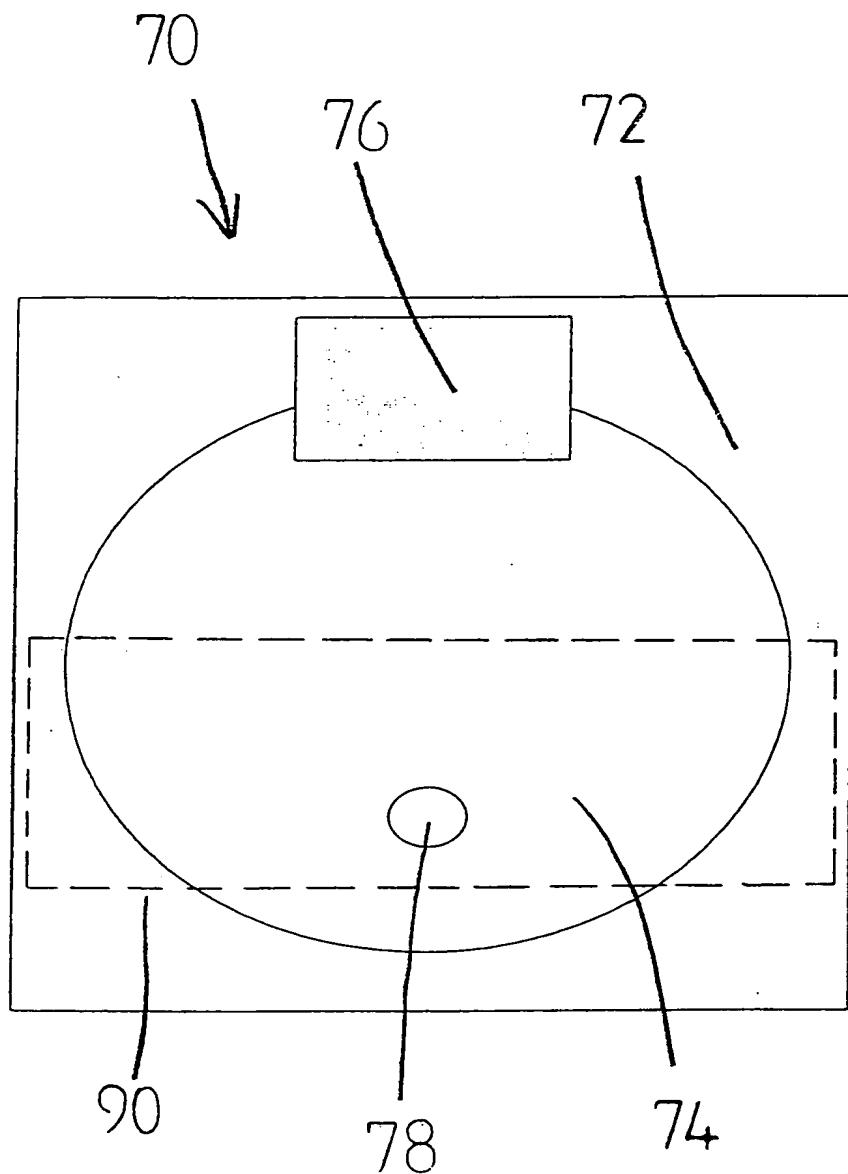


FIG 5

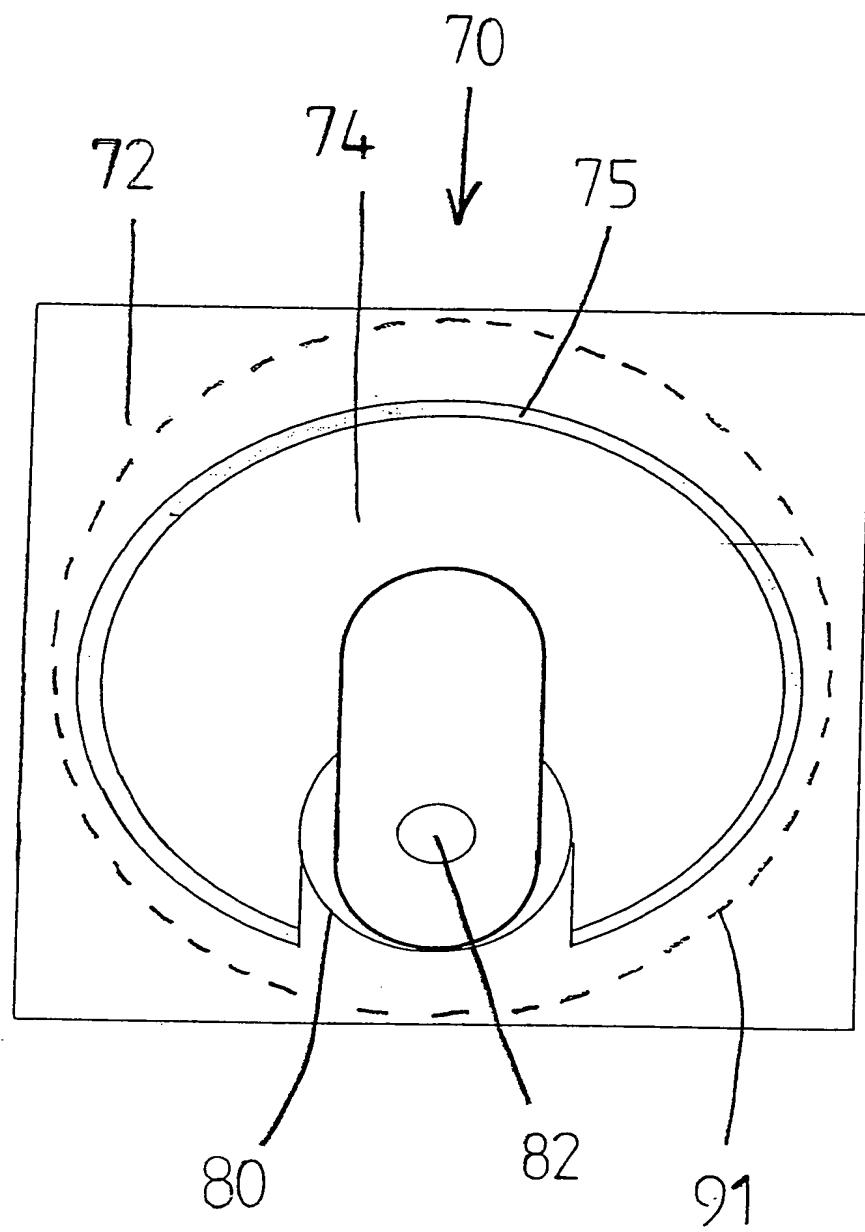


FIG 6

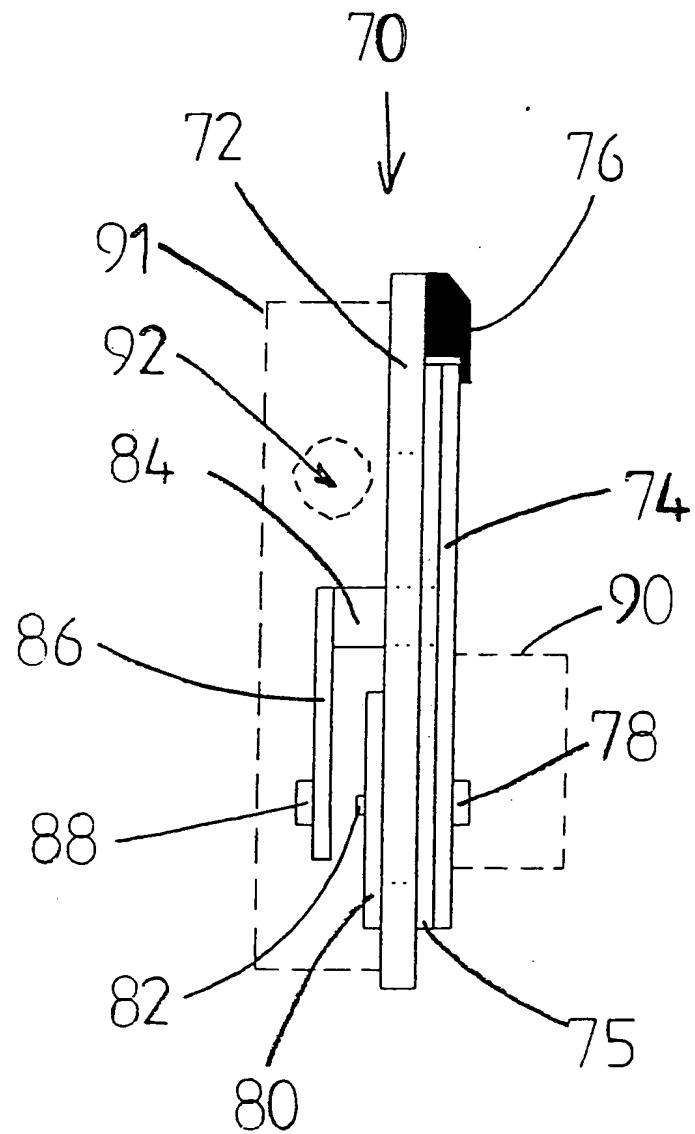


FIG 7